

CLAIMS:

1. A method of detecting defects in a railway track rail, the rail having a longitudinal centre plane and a surface, the surface including a running surface, the method comprising
 - 5 directing an excitation laser beam to an excitation position on the surface of the rail to induce an ultrasonic wave in the rail; and
 - 10 directing a detection laser beam to a detection position on the surface of the rail to detect at least one predetermined property of the induced ultrasonic wave;

characterised in that the excitation position and the detection position are

- 15 located on the running surface and displaced from the longitudinal centre plane of the rail.
2. A method according to claim 1, wherein the excitation position is located on a first side of the longitudinal centre plane and wherein the detection position is located on a second side of the longitudinal centre plane opposite the first side.
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3. A method according to claim 2, wherein the excitation position is displaced from the longitudinal centre plane by an excitation distance; and wherein the detection position is displaced from the longitudinal centre plane by a detection distance, the detection distance being substantially equal to the excitation distance.
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4. A method according to claim 2 or 3, wherein the rail comprises a rail web portion supporting a rail head, the rail web portion having a web waist defining a minimum cross sectional width of the rail web; and wherein the
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detection position is displaced from the excitation position in a cross direction of the rail by a transverse spot displacement corresponding to half the minimum cross sectional width of the rail web.

- 5 5. A method according to any one of claims 1 through 4, wherein the detection position is displaced in the longitudinal direction of the rail from the excitation position by a longitudinal spot displacement.
- 10 6. A method according to claim 5, wherein the rail comprises a rail head having a predetermined width; and wherein the longitudinal spot displacement corresponds to a half the width of the rail head.
- 15 7. A method according to any one of claims 2 through 6, further comprising detecting from the at least one predetermined property of the induced ultrasonic wave the presence or absence of a rail defect of a predetermined defect type; wherein the defect type is selected from the group of defect types consisting of a horizontal cracking at the web-head fillet radius, a horizontal crack of the rail head, a progressive crack of the head, and a complete rail break.
- 20 8. A method according to claim 1, wherein the rail comprises a gage side proximate to a centre of the railway track; and wherein the excitation position and the detection position are located on the gage side of the longitudinal axis.
- 25 9. A method according to claim 8, wherein the rail comprises a rail web portion supporting a rail head, the rail web portion having a web waist defining a minimum cross sectional width of the rail web; and wherein the detection position is displaced from the longitudinal centre plane by a detection distance corresponding to half the minimum cross sectional width of the rail.

10. A method according to claim 8 or 9, further comprising detecting from the at least one predetermined property of the induced ultrasonic wave the presence or absence of a rail defect of a predetermined defect type; wherein the defect type is selected from the group of defect types consisting of a
- 5 longitudinal vertical crack of the rail head and a long groove of the running surface.
11. A method according to any one of claims 1 through 10, wherein the excitation spot is an elongated spot.
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12. A method according to claim 11, wherein the elongated spot defines a longitudinal excitation spot direction, and wherein the longitudinal excitation spot direction is transverse with respect to the direction of the displacement of the detection position from the excitation position.
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13. A method according to any one of claims 1 through 12, wherein the detection position and the excitation position are moved along the longitudinal direction of the rail at a predetermined speed.
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14. A method according to any one of claims 1 through 13, wherein the detection laser is a continuous-wave laser connected to an optical interferometer.
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15. A method according to any one of claims 1 through 14, further comprising
 - receiving a scattered laser beam produced from the detection laser beam scattered at the surface of the rail and modulated corresponding to the ultrasonic wave with an optical interferometer;
 - generating an output signal of the optical interferometer representative of the ultrasonic wave.
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16. A method according to any one of claims 1 through 15, further comprising

- obtaining a first ultrasonic waveform corresponding to an ultrasonic wave induced into a first rail segment;
 - dividing the first ultrasonic waveform into a set of waveform segments;
 - determining at least a first waveform parameter indicative of at least one predetermined property of a first waveform segment;
- 5 – determining the first waveform segment as being indicative of the presence or absence of a rail defect in the first rail segment by comparing the determined first waveform parameter with at least one reference waveform parameter.
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17. An apparatus for detecting defects in a railway track rail, the rail having a longitudinal centre plane and a surface, the surface including a running surface, the apparatus comprising
- 15 an excitation laser arrangement adapted to direct an excitation laser beam to an excitation position on the surface of the rail to induce an ultrasonic wave in the rail; and
- 20 a detection laser arrangement adapted to direct a detection laser beam to a detection position on the surface of the rail to detect a predetermined property of the induced ultrasonic wave;
- characterised in that
- 25 the excitation laser arrangement and the detection laser arrangement are arranged to direct the excitation laser beam and the detection laser beam to respective excitation and detection positions located on the running surface and displaced from the longitudinal centre plane of the rail.
- 30 18. An apparatus according to claim 17, the apparatus further comprising a rail vehicle adapted to be moved along the rail; wherein the excitation laser

arrangement and the detection laser arrangement are mounted to the rail vehicle.

19. An apparatus according to claim 17 or 18, further comprising control
5 means for adjusting the incident angle of the detection laser beam on the running surface of the rail.

20. A method of detecting defects in a railway track rail, the method comprising

- 10 – obtaining a first ultrasonic waveform corresponding to an ultrasonic wave induced into a first rail segment;
– dividing the first ultrasonic waveform into a set of waveform segments;
– determining at least a first waveform parameter indicative of at least one predetermined property of a first waveform segment;
15 – determining the first waveform segment as being indicative of the presence or absence of a rail defect in the first rail segment by comparing the determined first waveform parameter with at least one reference waveform parameter.
- 20 21. A method according to claim 20, wherein the at least one predetermined property includes at least one of a standard deviation and a peak height.
22. A method according to claim 20 or 21, wherein the at least one reference waveform parameter includes at least one of a waveform parameter of a corresponding waveform segment of a calibration waveform and a waveform parameter of a second waveform segment of the first ultrasonic waveform, the second waveform segment being adjacent to the first waveform segment.
23. A method according to any one of claims 20 through 22, further
30 comprising determining a defect type and a defect location from a location

within the obtained waveform of at least one waveform segment determined as being indicative of the presence of a rail defect in the first rail segment.

24. A data processing system comprising

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means for obtaining a first ultrasonic waveform corresponding to an ultrasonic wave induced into a first rail segment; and

processing means adapted to

- 10 – divide the first ultrasonic waveform into a set of waveform segments;
- determine at least a first waveform parameter indicative of at least one predetermined property of a first waveform segment;
- determine the first waveform segment as being indicative of the presence or absence of a rail defect in the first rail segment by
- 15 comparing the determined first waveform parameter with at least one reference waveform parameter.

25. A computer program comprising program code means for performing all the steps of any one of the claims 20 through 23 when said program is run on
20 a computer.

26. A computer program product comprising program code means stored on a computer readable medium for performing the method of any one of the claims 20 through 23 when said computer program product is run on a
25 computer.